

What is claimed is

1. A system for reducing accidental explosion hazard of an aircraft fuel tank having a head space, comprising

(a) fuel scrubbing means for removing oxygen dissolved in a liquid aircraft fuel, in which the fuel scrubbing means is adapted to remove an amount of the oxygen from the fuel effective to produce a low concentration of dissolved oxygen of the fuel at which oxygen liberated from the fuel during flight produces an oxygen concentration of vapor in the head space not exceeding a preselected limit,

(b) head space inerting means for purging the head space with a substantially oxygen-free gas to provide an oxygen concentration of vapor in the head space of less than the preselected limit, and

(c) volatile organic compound removing means for separating substantially all volatile organic compound components present in a vapor produced by the fuel scrubbing means and the head space inerting means prior to emitting the vapor to ambient atmosphere,

in which all of the fuel scrubbing means, head space inerting means and volatile organic compound removing means are positioned on ground at an airport.

2. The system of claim 1 in which the fuel scrubbing means and the head space inerting means are adapted to reduce the oxygen concentration of the vapor to at most about 12 vol. %.

3. The system of claim 1 in which the fuel scrubbing means is adapted to produce a concentration of dissolved oxygen of at most about 5 parts per million by weight.

4. A system for reducing a hazard of accidental explosion of aircraft fuel tanks comprising at least one of

(A) a first supply of ultra high purity nitrogen gas comprising a means for removing water, carbon dioxide and airborne impurities from air thereby producing filtered air, a heat exchanger adapted to cool the filtered air and cryogenic distillation means for separating oxygen from the filtered air,

(B) a second supply of ultra high purity nitrogen comprising a tank containing pressurized, liquid nitrogen and a vaporizer means for vaporizing a stream of liquid nitrogen,

(C) an aircraft fuel bulk storage tank fuel scrubbing subsystem comprising, an aircraft fuel bulk storage tank, a gas-liquid mixing means for intimately mixing

a liquid aircraft fuel in turbulent flow with nitrogen gas from at least one of the first supply and the second supply of ultra high purity nitrogen, and a fuel circulation pump adapted to circulate the aircraft fuel in a flow loop through the bulk storage tank and the gas-liquid mixing means,

5 (D) a gas cleaning means for removing a volatile organic compound from a gas mixture generated by the aircraft fuel bulk storage tank fuel scrubbing subsystem, the gas mixture comprising nitrogen gas and the volatile organic compound,

10 (E) an aircraft fuel tank head spacing inerting subsystem comprising a membrane separation unit adapted to produce highly nitrogen enriched air from ambient air and a highly nitrogen enriched air distribution header operative to deliver the highly nitrogen enriched air to aircraft loading/boarding positions of a concourse of an airport, and

15 (F) an aircraft fuel tank head space venting system comprising a vapor transfer line from the concourse of the airport to the gas cleaning means, and means for removably connecting the vapor transfer line to the aircraft fuel tank head space of aircraft at the aircraft loading/boarding positions.

20 5. The system of claim 4 in which the gas cleaning means comprises a condensing heat exchanger which is operative to condense volatile organic compounds from the gas mixture, and a vent adapted to emit to ambient atmosphere nitrogen gas produced by the gas cleaning means which nitrogen gas is substantially free of the volatile organic compound components.

25 6. The system of claim 4 which comprises more than one element (A)-(F)

7. The system of claim 4 which comprises all of the elements (A)-(F).

30 8. The system of claim 4 in which the gas cleaning means is positioned proximate to the bulk storage tank and the system further comprises a second such gas cleaning means positioned proximate to the concourse and being adapted to receive nitrogen gas bearing volatile organic compound components discharged from the aircraft fuel tank head space.

35 9. The system of claim 8 in which the second gas cleaning means comprises a condensing heat exchanger operative to condense volatile organic compounds from

a mixture of nitrogen gas and such volatile organic compound, and a vent adapted to emit to ambient atmosphere nitrogen gas substantially free of the volatile organic compound.

5           10.     The system of claim 4 which further comprises a third supply of ultra high purity nitrogen positioned proximate to the concourse and comprising a tank containing liquid nitrogen and a vaporizer means for vaporizing a stream of liquid nitrogen, the third supply of ultra high purity nitrogen thereby providing an installed  
10           redundant source of nitrogen gas to the highly nitrogen enriched air distribution header in addition the nitrogen gas provided by the membrane separation unit.

          11.     The system of claim 6 which comprises a plurality of at least one of those of elements (A)-(F) and in which the plural elements are manifolded together to form a nitrogen gas supply grid, thereby allowing nitrogen gas to be consumed anywhere  
15           within the grid without depending upon operability of any particular one of the plural elements.

          12.     The system of claim 6 further comprising  
                  (A) a plurality of aircraft fuel bulk liquid storage tanks, each tank  
20           comprising a headspace vent, a high purity nitrogen supply, and a vapor control system adapted to control feed of the high purity nitrogen gas and a discharge of an exhaust gas through the headspace vent, thereby maintaining the pressure and concentration of gas in the tank at a desired set point,

                  (B) a common discharge transfer line adapted to receive scrubbed aircraft  
25           fuel from all of the plurality of bulk liquid storage tanks,

                  (C) an eductor adapted to receive and contact raw aircraft fuel containing dissolved oxygen with nitrogen gas, thereby transferring oxygen from solution in the fuel to the nitrogen gas and producing scrubbed fuel,

                  (D) a separator operative to segregate the scrubbed fuel from the nitrogen  
30           gas containing oxygen of (C),

                  (E) a liquid transfer conduit to feed scrubbed fuel from the separator to the bulk liquid storage tanks,

                  (F) a fuel recovery unit adapted to condense aircraft fuel vapor entrained in the nitrogen gas containing oxygen of (C), and

35           (G) a gas stream transfer line in vapor communication with the separator, the fuel recovery unit and the vent of each tank.